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SOYBEAN PROTEIN

Allan K. Smith
U. S. Regional Soybean Industrial Products Laboratory 1/
Urbana, Illinois

The large quantities of soybean meal left from the solvent extraction of oil from soybeans may be considered as a practically unlimited raw material for the production of soybean protein. If 10 percent of the 1941 crop of soybeans, estimated at 107 million bushels, were processed for protein, we would have approximately a quarter of a billion pounds of this product. It is thus evident that raw material supplies are more than adequate for all visible needs.

Soybean protein is a relatively new commodity on our markets, and in order to find a permanent place among other competing industrial proteins, synthetic adhesives, and plastics, it must meet competition in regard to both quality and cost. It is not possible at this early stage of development to present trustworthy data relative to the cost of refining soybean protein. As regards cost of materials, however, the situation is very promising. If we take the value of solvent-extracted, oil-free meal in normal times at 1-1/2 cents per pound and the protein content as 44 percent, we have an initial cost of unrefined protein of about 3.4 cents per pound, ascribing no value to the nonprotein fraction of the meal. On this basis a liberal allowance can be made for processing costs and still there will remain a satisfactory price range to compete with other protcins which normally sell for 12 to 16 cents per pound.

The U. S. Regional Soybean Industrial Products Laboratory has made an extensive laboratory investigation of methods for separating the protein from the meal and is continuing these studies along with research on chemical and physical properties of the protein. The results obtained show that the separation of the unmodified protein on a small scale by extraction of the meal with water or dilute alkali and subsequent precipitation with acid is not difficult. Extraction data for acids, bases, and salts are illustrated in Figures 1 and 2. On the other hand, the engineering problems such as clarification, filtration, centrifugation, drying, and grinding which are encountered at various stages of large-scale production are not well understood and might offer considerable difficulty to anyone undertaking commercial production.

1/ A cooperative organization participated in by the Bureaus of Agricultural Chemistry and Engineering and Plant Industry of the U. S. Department of Agriculture, and the Agricultural Experiment Stations of the North Central States of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

There is also the problem of modifying the properties of soybean protein by chemical treatment to make it suitable for specific uses. This problem deserves a great deal of scientific investigation, and its solution will be the principal means of extending the industrial utilization of soybean protein and probably other proteins as well.

Soybean protein is comparatively new in the field of industrial proteins, which include casein, gelatin, blood albumin, egg white, fish glue, and zein. These proteins have various physical and chemical characteristics in common, yet each one possesses an individuality which leads to some specific use. Proteins have the most complicated molecular structures of any substances with which the chemist works, and for this reason truly chemical exploitation will be slow.

Soybean protein resembles casein more closely than any other protein, and in the early attempts to introduce it to industry it was called "soybean casein" with the object of trading on the good name of an already established product. In the long run, however, soybean protein must find its place in industry on its own merits, and any attempt to confuse it with casein or other protein cannot be considered a sound policy.

While the isolation of soybean protein on a small scale is a relatively simple matter for a chemist, it should be pointed out that its production on a large scale and its utilization by industry require considerable technical skill and will result in disappointment to those attempting commercial processing without a careful study of the problems involved. Furthermore, when soybean protein is recommended for certain uses, one should not expect that it can be substituted in formulas established for other proteins with the same results, but rather that specific or modified formulas will be required. It should be considered as a technical product and sold accordingly.

As intimated above, soybean protein may be modified during the refining process so as to alter its solubility or dispersing characteristics, its adhesive strength, viscosity, color, and tolerance for formaldehyde. The simplest modifications are effected by a mild hydrolytic treatment with dilute alkali or by the action of proteolytic enzymes. These treatments alter several of the properties of soybean protein; for example, they make it more easily dispersible. Research is in progress on the substitution of organic groups in the protein molecule, because an appreciable change in physical and chemical properties may be expected from this type of chemical alteration.

Indications are that soybean protein will find substantial use in paper coatings, paper sizing, water paints, plastics for buttons and buckles, leather dressings, and adhesives for various purposes, such as making furniture and abrasive paper. Research is in progress toward the production of a wool-like fiber from soybean protein. Such a project, if successful, might consume a considerable tonnage of the protein.

The largest use of soybean protein in immediate prospect is for paper coating. Up to the present time soybean protein has not been completely acceptable for all grades of paper coatings, largely because it is slightly darker in color than casein. Recent work at the Soybean Laboratory indicates that a satisfactory bleach for soybean protein may have been found in sodium dithionite ($Na_2S_2O_4$) or zinc dithionite (ZnS_2O_4). It has been shown in the laboratory that 4 or 5 percent of one of these powerful reducing agents on the basis of the protein, added at the time of preparing the coating color results in a paper coating as bright in color as that prepared with a good grade of casein. This bleaching development is still to be proved satisfactory in plant production and printing tests, but the simplicity of operation favors its success. Since the beginning of the war emergency, much of the normal casein supply has been diverted to dry milk production, and we have an increasing shortage of milk casein. Commercial soybean protein which has been developed to the stage where it may satisfactorily take the place of casein in the paper trade can help to fill in this shortage. Perhaps more important in the present emergency than paper coating, however, is that portion of the plywood industry which depends upon casein as an adhesive and which consumes an estimated 200 tons of casein per month. An increased production of soybean protein would help to relieve the general industrial protein demand and aid in this essential war need.

It is impossible to predict at this early stage of research and development what the future may be for soybean protein as an industrial product, but with all things considered it has many promising possibilities.

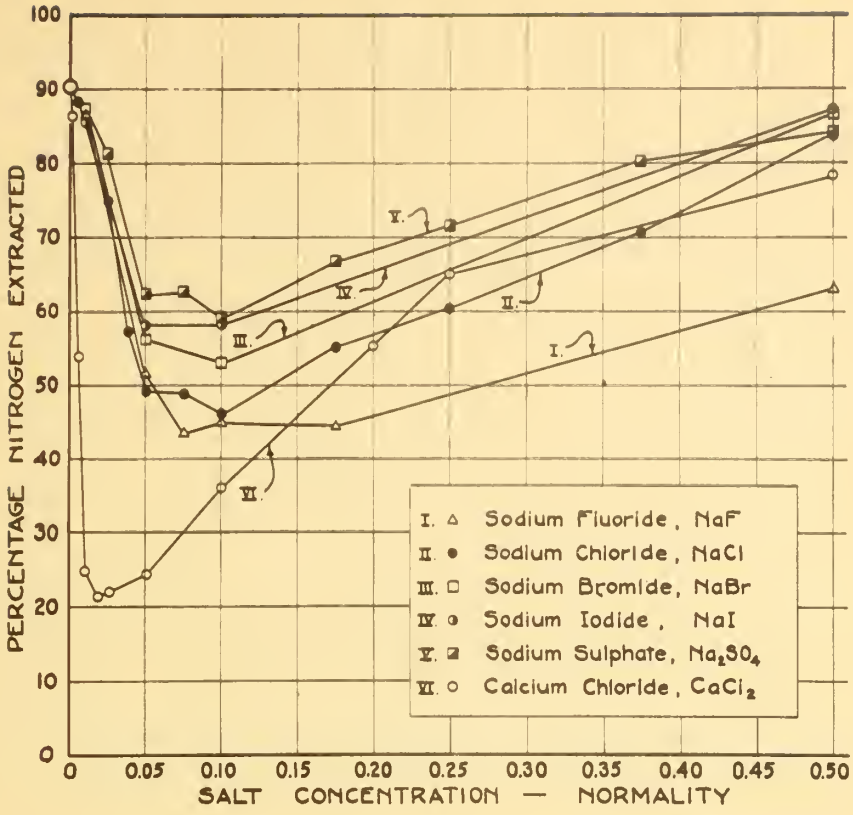

Fig. 1. Data showing the extraction of nitrogen from oil-free soybean meal by various salts and by water. 2.5 g. of meal was extracted with 100 cc. of solution. (See J. Am. Chem. Soc. 60, 1316 (1938) for original publication.)

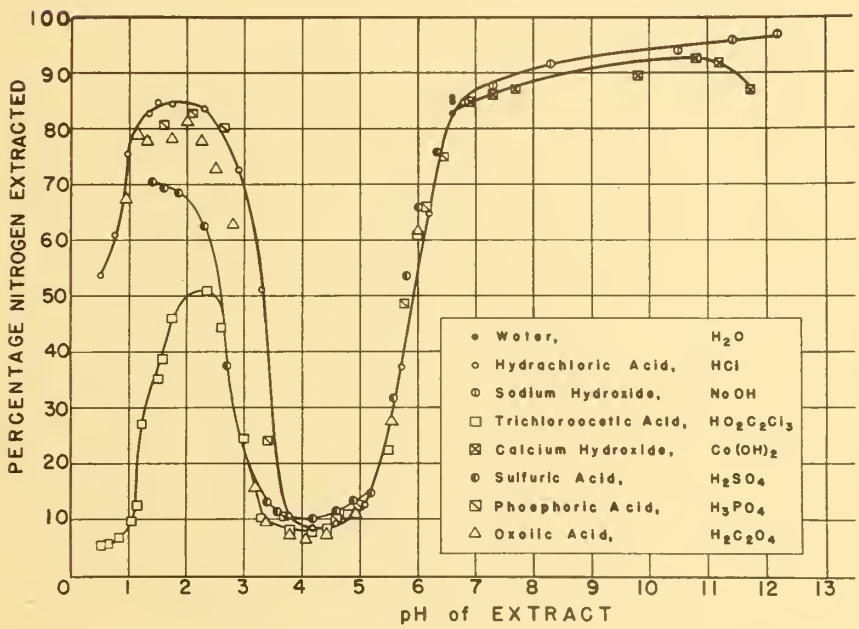

Fig. 2. Data showing the extraction of nitrogen from oil-free soybean meal with acids and alkalies. 2.5 g. of meal was extracted with 100 cc. of solution. (See Ind. Eng. Chem. 30, 1414 (1938) for original publication.)